



Indiana Department of Education

Indiana Academic Standards Mathematics: Analytical Algebra II



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Introduction

The Indiana Academic Standards for Mathematics are the result of a process designed to identify, evaluate, synthesize, and create the most high-quality, rigorous standards for Indiana students. The standards are designed to ensure that all Indiana students, upon graduation, are prepared for both college and career opportunities. In alignment with Indiana's Every Student Succeeds Act (ESSA) plan, the academic standards reflect the core belief that all students can achieve at a high level.

What are the Indiana Academic Standards?

The Indiana Academic Standards are designed to help educators, parents, students, and community members understand what students need to know and be able to do at each grade level, and within each content strand, in order to exit high school college and career ready. The academic standards should form the basis for strong Tier 1 instruction at each grade level and for each content area for all students, in alignment with Indiana's vision for Multi-Tiered Systems of Supports (MTSS). While the standards have identified the academic content or skills that Indiana students need to be prepared for both college and career, they are not an exhaustive list. Students require a wide range of physical, social, and emotional support to be successful. This leads to a second core belief outlined in Indiana's ESSA plan that learning requires an emphasis on the whole child.

While the standards may be used as the basis for curriculum, the Indiana Academic Standards are not a curriculum. Curricular tools, including textbooks, are selected by the district/school and adopted through the local school board. However, a strong standards-based approach to instruction is encouraged, as most curricula will not align perfectly with the Indiana Academic Standards. Additionally, attention should be given at the district and school-level to the instructional sequence of the standards as well as to the length of time needed to teach each standard. Every standard has a unique place in the continuum of learning - omitting one will certainly create gaps - but each standard will not require the same amount of time and attention. A deep understanding of the vertical articulation of the standards will enable educators to make the best instructional decisions. The Indiana Academic Standards must also be complemented by robust, evidence-based instructional practices, geared to the development of the whole child. By utilizing well-chosen instructional practices, social-emotional competencies and employability skills can be developed in conjunction with the content standards.

Acknowledgments

The Indiana Academic Standards have been developed through the time, dedication, and expertise of Indiana's K-12 teachers, higher education professors, and other representatives. The Indiana Department of Education (IDOE) acknowledges the committee members who dedicated many hours to the review and evaluation of these standards designed to prepare Indiana students for college and careers.

PROCESS STANDARDS FOR MATHEMATICS



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The Process Standards demonstrate the ways in which students should develop conceptual understanding of mathematical content, and the ways in which students should synthesize and apply mathematical skills.

PROCESS STANDARDS FOR MATHEMATICS

PS.1: Make sense of problems and persevere in solving them.	Mathematically proficient students start by explaining to themselves the meaning of a problem and looking for entry points to its solution. They analyze givens, constraints, relationships, and goals. They make conjectures about the form and meaning of the solution and plan a solution pathway, rather than simply jumping into a solution attempt. They consider analogous problems and try special cases and simpler forms of the original problem in order to gain insight into its solution. They monitor and evaluate their progress and change course if necessary. Mathematically proficient students check their answers to problems using a different method, and they continually ask themselves, “Does this make sense?” and “Is my answer reasonable?” They understand the approaches of others to solving complex problems and identify correspondences between different approaches. Mathematically proficient students understand how mathematical ideas interconnect and build on one another to produce a coherent whole.
PS.2: Reason abstractly and quantitatively.	Mathematically proficient students make sense of quantities and their relationships in problem situations. They bring two complementary abilities to bear on problems involving quantitative relationships: the ability to decontextualize—to abstract a given situation and represent it symbolically and manipulate the representing symbols as if they have a life of their own, without necessarily attending to their referents—and the ability to contextualize, to pause as needed during the manipulation process in order to probe into the referents for the symbols involved. Quantitative reasoning entails habits of creating a coherent representation of the problem at hand; considering the units involved; attending to the meaning of quantities, not just how to compute them; and knowing and flexibly using different properties of operations and objects.
PS.3: Construct viable arguments and critique the reasoning of others.	Mathematically proficient students understand and use stated assumptions, definitions, and previously established results in constructing arguments. They make conjectures and build a logical progression of statements to explore the truth of their conjectures. They analyze situations by breaking them into cases



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	<p>and recognize and use counterexamples. They organize their mathematical thinking, justify their conclusions and communicate them to others, and respond to the arguments of others. They reason inductively about data, making plausible arguments that take into account the context from which the data arose. Mathematically proficient students are also able to compare the effectiveness of two plausible arguments, distinguish correct logic or reasoning from that which is flawed, and—if there is a flaw in an argument—explain what it is. They justify whether a given statement is true always, sometimes, or never. Mathematically proficient students participate and collaborate in a mathematics community. They listen to or read the arguments of others, decide whether they make sense, and ask useful questions to clarify or improve the arguments.</p>
PS.4: Model with mathematics.	<p>Mathematically proficient students apply the mathematics they know to solve problems arising in everyday life, society, and the workplace using a variety of appropriate strategies. They create and use a variety of representations to solve problems and to organize and communicate mathematical ideas. Mathematically proficient students apply what they know and are comfortable making assumptions and approximations to simplify a complicated situation, realizing that these may need revision later. They are able to identify important quantities in a practical situation and map their relationships using such tools as diagrams, two-way tables, graphs, flowcharts and formulas. They analyze those relationships mathematically to draw conclusions. They routinely interpret their mathematical results in the context of the situation and reflect on whether the results make sense, possibly improving the model if it has not served its purpose.</p>
PS.5: Use appropriate tools strategically.	<p>Mathematically proficient students consider the available tools when solving a mathematical problem. These tools might include pencil and paper, models, a ruler, a protractor, a calculator, a spreadsheet, a computer algebra system, a statistical package, or dynamic geometry software. Mathematically proficient students are sufficiently familiar with tools appropriate for their grade or course to make sound decisions about when each of these tools might be helpful, recognizing both the insight to be gained and their limitations. Mathematically proficient students identify relevant external mathematical resources, such as digital content, and use them to pose or solve problems. They use technological tools to explore and deepen their understanding of concepts and to support the development of learning mathematics. They</p>



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	use technology to contribute to concept development, simulation, representation, reasoning, communication and problem solving.
PS.6: Attend to precision.	Mathematically proficient students communicate precisely to others. They use clear definitions, including correct mathematical language, in discussion with others and in their own reasoning. They state the meaning of the symbols they choose, including using the equal sign consistently and appropriately. They express solutions clearly and logically by using the appropriate mathematical terms and notation. They specify units of measure and label axes to clarify the correspondence with quantities in a problem. They calculate accurately and efficiently and check the validity of their results in the context of the problem. They express numerical answers with a degree of precision appropriate for the problem context.
PS.7: Look for and make use of structure.	Mathematically proficient students look closely to discern a pattern or structure. They step back for an overview and shift perspective. They recognize and use properties of operations and equality. They organize and classify geometric shapes based on their attributes. They see expressions, equations, and geometric figures as single objects or as being composed of several objects.
PS.8: Look for and express regularity in repeated reasoning.	Mathematically proficient students notice if calculations are repeated and look for general methods and shortcuts. They notice regularity in mathematical problems and their work to create a rule or formula. Mathematically proficient students maintain oversight of the process, while attending to the details as they solve a problem. They continually evaluate the reasonableness of their intermediate results.



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MATHEMATICS: Analytical Algebra II

Data Analysis, Statistics, and Probability

Guiding Principle: Data analysis, statistics, and probability content should be included throughout the course, as students collect and use univariate and bivariate data to create and interpret mathematical models. They should be able to make inferences and justify conclusions from various experimental and survey data, and develop a basic understanding of the structure of a good study, the biases that might exist, and the importance of randomization.

AA.DSP.1	Make inferences and justify conclusions from sample surveys, experiments, and observational studies. Recognize the purposes of and differences among sample surveys, experiments, and observational studies; explain how randomization and possible sources of bias relate to each.
AA.DSP.2	Choose, create, and critique, with technology, mathematical models (linear, quadratic and exponential) for bivariate data sets. Use the models to interpolate and/or extrapolate, to answer questions, and to draw conclusions or make decisions, addressing limitations and long-term ramifications. Recognize when a change in model is needed. Interpret the correlation coefficient for linear models.
AA.DSP.3	Read, interpret, and make decisions about data summarized numerically using measures of center and spread, in tables, and in graphical displays (line graphs, bar graphs, scatterplots, and histograms), e.g., explain why the mean may not represent a typical salary; critique a graphical display by recognizing that the choice of scale can distort information.
AA.DSP.4	Analyze and compare univariate data of two or more different data sets using measures of center (mean, median, and mode), shape, and spread (range, interquartile range, standard deviation, percentiles, and variance) making use of technology. Understand the effects of outliers on the statistical summary of the data.
AA.DSP.5	Record multiple observations (or simulated samples) of random events and construct empirical models of the probability distributions. Construct a theoretical model and apply the law of large numbers to show the relationship between the two models.



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AA.DSP.6	Evaluate the validity of claims based on empirical probabilities and theoretical probabilities, including those derived from dependent and independent events. Draw conclusions and make decisions in various probabilistic contexts. Make use of different representations of data including two-way tables and tree diagrams.
AA.DSP.7	Determine the nature and number of elements in a finite sample space to model the outcomes of real-world events using the Fundamental Counting Principle, permutations, and combinations.



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Linear Functions and Beyond

Guiding Principle: Extending from work with linear functions in Algebra I, this content should include work with arithmetic sequences and series, understanding the relationship to linear functions. Additionally, students should solidify their understanding of systems of equations. The focus should be on solving systems of equations that represent real-world situations, with technology. Students should be able to solve systems that involve nonlinear equations. They should also be able to solve systems of equations with three variables with technology, using various strategies such as matrices.

AA.LF.1	Model real world situations involving arithmetic sequences and understand that they can be defined both recursively and with an explicit formula.
AA.LF.2	Find partial sums of arithmetic series that model real world situations.
AA.LF.3	Recognize functional relationships in real world contexts. Translate fluently among multiple representations (graphs, tables, equations, and verbal descriptions).
AA.LF.4	Within real world contexts, understand composition of functions and combine functions by composition.
AA.LF.5	Explore and describe the effect on the graph of $f(x)$ by replacing $f(x)$ with $f(x) + k$, $kf(x)$, $f(kx)$, and $f(x + k)$ for specific values of k (both positive and negative) with and without technology. Find the value of k given the graph of $f(x)$ and the graph of $f(x) + k$, $kf(x)$, $f(kx)$, or $f(x + k)$.
AA.LF.6	Represent and solve real-world problems using a system of equations and/or inequalities consisting of a linear equation and a quadratic equation in two variables with technology.



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AA.LF.7	Represent real-world problems using a system of linear equations and/or inequalities in two or three variables. Solve such systems graphically or with matrices, as appropriate to the system, with technology. Interpret the solution and determine whether it is reasonable.
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Quadratic and Other Polynomial Functions

Guiding Principle: Extending from Algebra I, students should be able to represent real-world problems that can be modeled with quadratic or higher-order polynomial functions, interpreting key attributes in a given context.

AA.QP.1	Represent real-world problems that can be modeled with quadratic functions using tables, graphs, and equations; translate fluently among these representations. Solve such problems with technology. Interpret the solutions and determine whether they are reasonable.
AA.QP.2	Understand that different forms of a quadratic equation can provide different information. Identify and interpret within a given context the vertex, intercepts, zeros, domain and range, and lines of symmetry.
AA.QP.3	Represent real-world problems that can be modeled with polynomial functions using graphs and equations. Solve such problems with technology. Interpret the solutions and determine whether they are reasonable.
AA.QP.4	Graph polynomial functions that model a real-world situation with technology. Identify, describe, and interpret key features in the context of the situation, such as intercepts, zeros, domain and range, end behavior, maxima and minima, and lines of symmetry.



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Exponential and Logarithmic Functions

Guiding Principle: Extending from initial work with exponential functions in Algebra I, students should understand the relationship between logarithmic and exponential functions. Additionally, this content should include representing real-world problems that can be modeled with either exponential or logarithmic functions, interpreting key attributes in a given context. Arithmetic and geometric sequences and series should also be introduced, making the connection to linear and exponential functions respectively.

AA.EL.1	Model real world situations involving geometric sequences and understand that they can be defined both recursively and with an explicit formula.
AA.EL.2	Find partial sums of geometric series that model real world situations.
AA.EL.3	Represent real-world problems using exponential functions in one or two variables and solve such problems with technology. Interpret the solutions and determine whether they are reasonable.
AA.EL.4	Graph exponential functions that model real-world situations with technology. Identify, describe, and interpret key features, such as intercepts, zeros, domain, range, asymptotic and end behavior.
AA.EL.5	Given real-world contexts, identify the percent rate of change in exponential functions. Classify them as representing exponential growth or decay.
AA.EL.6	Analyze growth and decay using absolute and relative change and make comparisons using absolute and relative difference.



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AA.EL.7	Know that the inverse of an exponential function is a logarithmic function. Represent exponential and logarithmic functions that model real-world situations using graphing technology and describe their inverse relationship. Use the inverse relationship between exponential functions and logarithms to evaluate expressions and solve equations in one variable.
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Rational, Radical, and Other Functions

Guiding Principle: This content should include representing real-world problems that can be modeled with rational, radical, and piecewise-defined functions. Students should be able to translate between various representations and interpret key attributes in a given context.

AA.R.1	Represent and solve real-world problems that can be modeled with rational functions using tables, graphs, and equations. Graph rational functions with technology. Identify, describe, and interpret features, such as intercepts, zeros, asymptotes, domain and range, and end behavior.
AA.R.2	Represent and solve real-world problems that can be modeled with radical functions using tables, graphs, and equations. Graph radical functions with technology. Identify, describe, and interpret features, such as intercepts, zeros, asymptotes, domain and range, and end behavior.
AA.R.3	Graph real-world functions including polynomial, rational, square root, step functions, absolute value functions, and piecewise-defined functions with technology. Identify and describe features, such as intercepts, domain and range, end behavior, asymptotic behavior, and/or lines of symmetry